WATER RESOURCES REPORT 6

WATER POSSIBILITIES FROM THE GLACIAL DRIFT OF LIVINGSTON COUNTY

BY

DALE L. FULLER

J. R. McMILLEN

HARRY PICK

W. B. RUSSELL

JACK WELLS

MISSOURI GEOLOGICAL SURVEY AND WATER RESOURCES

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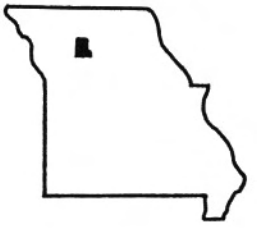
Dale L. Fuller, J. R. McMillen, Harry Pick,
W. B. Russell, and Jack Wells



1956
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MISSOURI GEOLOGICAL SURVEY AND WATER RESOURCES ROLLA, MO.

William C. Hayes, State Geologist and Director

WATER POSSIBILITIES FROM THE GLACIAL DRIFT OF LIVINGSTON COUNTY

A special study of groundwater by the Missouri Geological Survey and Water Resources was made possible at the 1955 session of the Missouri Legislature. With the approval of the Governor, money was appropriated from the Missouri Post War Surplus Reserve Fund.

Since nearly two-thirds of the counties located north of the Missouri River are deficient in water supplies, much of the effort of this special study is being directed toward the problems of this area.

It has been shown that a program of test drilling can locate new reserves of groundwater. Potential areas are being tested so that additional supplies will be available for domestic, irrigation, industrial and municipal needs.

The most favorable areas are in the sand and gravel filled channels and valleys of pre-glacial and inter-glacial streams. Since these buried valleys do not conform to present day drainage patterns, a systematic program of test drilling is a principal means of locating the channels and mapping their extent. Such glacial deposits have proved to be excellent sources of groundwater.

QUALITY OF WATER FROM ROCK WELLS

The water from the consolidated rock formations which underlie Livingston County is, for the most part, mineralized. The following are analyses from water wells and oil tests:

CONSTITUENTS	IN PARTS PER MILLION				
	A	B	C	D	E
Turbidity	10	turbid	turbid	4	turbid
Odor	none		none	none	none
pH	8.05			7.7	
Alkalinity ($CaCO_3$)	670.5	473.8	487.7	690.5	624.4
Phenolpthalein	52.0			56.0	
Methyl Orange	618.5			634.5	
Carbonate (CO_3)	31.2	4.1	5.5	33.6	2.8

CONSTITUENTS	IN PARTS PER MILLION				
	A	B	C	D	E
Bicarbonate (HCO_3)	754.6	573.6	589.1	774.1	761.5
Silica (SiO_2)	6.1	6.8	9.6	4.7	6.0
Oxides (Al_2O_3, Fe_3, TiO_2, etc.)	1.7	2.40*	1.60*	1.7	2.27[1]
Calcium (Ca)	7.3	61.8	41.4	11.3	48.0
Magnesium (Mg)	4.8	31.3	23.9	5.6	30.4
Sodium (Na) and Potassium (K) as Na	714.5	2369.1	2089.0	950.5	2557.1
Total Manganese (Mn)	0.00			0.00	
Total Iron (Fe)	1.72			0.32	12.09
Dissolved Iron	0.13			0.07	0.09
Precipitated Iron	1.59			0.25	12.00
Sulfate (SO_4)	288.1	830.0	698.5	609.1	678.8
Chloride (CI)	412.5	2868.6	2380.4	497.5	3139.6
Nitrate (NO_3)	3.3			0.9	00
Fluoride (F)	1.4	1.75	2.9	1.4	
Total Suspended Matter	9.			0.	
Total Dissolved Solids	1909.	6712.0	5743.0	2478.	6740.0
Total Hardness	38.0	282.8	201.5	51.2	244.6
Carbonate Hardness	38.0	282.8	201.5	51.2	244.6
Non-carbonate Hardness	0.0			none	
Percent of Alkalies	98	95	96	98	96

*Al_2O_3, Fe_2O_3
[1] Al_2O_3 only

CONSTITUENTS	IN PARTS PER MILLION				
	F	G	H	I	J
Turbidity	turbid	turbid	turbid	turbid	turbid
Odor					
pH					
Alkalinity ($CaCO_3$)	858.6	599.5	187.9		265.2
Phenolpthalein					
Methyl Orange					
Carbonate (C03)	16.7	37.3	00		00
Bicarbonate (HCO_3)	1030.1	693.2	229.2		323.4
Silica (SiO_2)	8.8	6.8	0.8		11.2
Oxides (Al_2O_3, Fe_2O_3, TiO_2, etc.)	1.60*	3.20*	2.40*		2.80*
Calcium (Ca)	29.0	6.5	292.2		317.6
Magnesium (Mg)	15.0	2.0	160.7		113.3
Sodium (Na) and Potassium (K) as Na	2153.9	1337.6	3054.4		3303.8
Total Manganese (Mn)					
Total Iron (Fe)					
Dissolved Iron					
Precipitated Iron					
Sulfate (SO_4)	16.9	73.0	1437.2	1507.7	1531.6
Chloride (CI)	2748.4	1540.6	4631.4	4813.2	4813.2

CONSTITUENTS	IN PARTS PER MILLION				
	F	G	H	I	J
Nitrate (NO_3)					
Fluoride (F)		3.10	2.00		3.00
Total Suspended Matter					
Total Dissolved Solids	5889.0	3454.0	10403.0	11315.0	11220.0
Total Hardness	134.0	24.5	1389.4		1258.5
Carbonate Hardness	134.0	24.5	187.9		265.2
Non-carbonate Hardness					
Percent of Alkalies	97	99	83		85

*Al_2O_3, Fe_2O_3

CONSTITUENTS	IN PARTS PER MILLION				
	K	L	M	N	O
Turbidity	turbid	turbid	turbid	turbid	slightly
Odor					stale
pH					7.4
Alkalinity ($CaCo_3$)	204.1	344.7	317.1	322.8	309.0
Phenolpthalein					24.0
Methyl Orange					285.0
Carbonate (CO_3)	00	00	00	00	14.4
Bicarbonate (HCO_3)	248.9	420.4	386.7	393.7	347.7
Silica (SiO_2)	6.0	13.6	6.0	31.6	8.0
Oxides (Al_2O_3, Fe_2O_3, TiO_2, etc.)	2.40*	1.60*	1.60*	2.00*	10.0
Calcium (Ca)	300.2	314.7	308.1	327.7	248.9
Magnesium (Mg)	170.9	206.8	196.6	192.4	126.5
Sodium (Na) and Potassium (K) as Na	3411.6	2604.3	2734.1	2579.9	2660.3
Total Manganese (Mn)					0.00
Total Iron (Fe)					9.00
Dissolved Iron					8.85
Precipitated Iron					0.15
Sulfate (S04)	1538.0	1472.6	1460.8	1478.3	1379.9
Chloride (CI)	4861.1	3760.6	3932.9	3731.9	3567.5
Nitrate (NO3)					0.0
Fluoride (F)	6.75	3.00	2.00	3.75	
Total Suspended Matter					497.
Total Dissolved Solids	11703.0	9490.0	9677.0	9315.0	8216.
Total Hardness	1451.2	1634.6	1576.3	1608.1	1142.2
Carbonate Hardness	204.1	344.7	317.1	322.8	309.0
Non-carbonate Hardness					833.2
Percent of Alkalies	89	77	79	78	84

*Al_2O_3, Fe_2O_3

CONSTITUENTS	IN PARTS PER MILLION		
	P	Q	R
Turbidity	slightly		6
Odor	none		none
pH			
Alkalinity ($CaCO_3$)	437.7		554.5
Phenolpthalein			30.0
Methyl Orange			524.5
Carbonate (CO_3)	34.2		18.0
Bicarbonate (HCO_3)	533.8		639.9
Silica (SiO_2)	9.2		4.8
Oxides (Al_2O_3, Fe_2O_3, TiO_2, etc.)			1.5
Calcium (Ca)	11.6	311.1	6.5
Magnesium (Mg)	3.6	136.4	3.1
Sodium (Na) and Potassium (K) as Na	347.6	2723.0[2]	534.3
Total Manganese (Mn)			0.00
Total Iron (Fe)	0.75		2.03
Dissolved Iron	0.15		0.16
Precipitated Iron	0.60		1.87
Sulfate (SO_4)	70.0	1285.9	0.8
Chloride (Cl)	152.2	4246.8	442.5
Nitrate (NO_3)	0.92		0.0
Fluoride (F)			1.4
Total Suspended Matter	13.6		18.
Total Dissolved Solids	937.0		1324.
Total Hardness	43.8	714.8	29.0
Carbonate Hardness	43.8		29.0
Non-carbonate Hardness			0.0
Percent of Alkalies	95		98

[2]Sodium (Na)

A. Owner: Gordon Fender, NE¼ NW¼ NW¼ sec. 5, T. 59 N., R. 25 W. Total depth 205 feet of which 30 feet is drift. Water sample from the Pennsylvanian System. Water sample from tap after having passed through the pressure tank. Collected August 27, 1956. Analyst: M. E. Phillips.

B. Owner: Bradley Bros., Jones et al. H. Kessler farm, center sec. 16, T. 59 N., R. 25 W. Total depth 648 feet in Spergen or Upper Warsaw formation of the Mississippian System. Sample from the Cherokee series of the Pennsylvanian System at a depth of 580 feet. Sampled Setember 30, 1940.

C. As "B". Sample also from the Cherokee series at a depth of 648 feet. Analyzed October 15, 1940 by R. T. Rolufs.

D. Owner: Mrs. Iris K. Breeden, NE¼ SE¼ SE¼ sec. 29, T. 59 N., R. 25 W. Total depth 200 feet. Sample collected September 5, 1956. Analyst: M. E. Phillips.

E. Owner: James R. Campbell, sec. 21, T. 58 N., R. 24 W. Total depth

750 feet. Water horizon probably from the Mississippian System. It was a flowing well. Analyzed November 9, 1935 by R. T. Rolufs.

F. Owner: Davis Bros. et al. Jerry Mining farm, SE¼ SE¼ NW¼ sec. 22, T. 58 N., R. 23 W. Total Depth 1225 feet bottomed St. Peter formation of the Ordovician System. Sample from 535 feet?, the top of the Mississippian System. Analyzed July 29, 1939 by R. T. Rolufs.

G. As "F" above. Sample from Warsaw or Keokuk-Burlington formations at 570 feet. The water from overlying formations was shut out. Analyzed October 17, 1939 by R. T. Rolufs.

H. As "F". Sample from the Devonian System at a depth of 1010 feet. Casing was set at 795 feet excluding all water above the Devonian. Analyzed October 17, 1939 by R. T. Rolufs.

I. As "F". Sample from the Kimmswick formation of the Ordovician System at a depth of 1085 feet. Analyzed October 10, 1939 by R. T. Rolufs.

J. As "F". Sample from the Kimmswick formation of the Ordovician System at a depth of 1085 feet. Analyzed October 17, 1939 by R. T. Rolufs.

K. As "F". Sample from the Kimmswick formation of the Ordovician System at a depth of 1105 feet. Analyzed October 17, 1939 by R. T. Rolufs.

L. As "F". Sample from the Kimmswick formation of the Ordovician System at a depth of 1130 feet. Analyzed October 25, 1939 by R. T. Rolufs.

M. As "F". Sample from the Kimmswick-Decorah formational contact at a depth of 1195 feet. Sample analyzed October 25, 1939 by R. T. Rolufs.

N. As "F". Sample from total depth of the well, 1225 feet, in the St. Peter formation of the Ordovician System. Sample analyzed October 25, 1939 by R. T. Rolufs.

O. Owner: John Hahsler, NE¼ NE¼ NE¼ sec. 20, T. 58 N., R. 22 W. Total depth 482 feet. Yield 1½ (?) gallons per minute. Static water level 341 feet. Water is from the Pennsylvanian and Mississippian Systems. Sampled August 26, 1955. Analyst: M. E. Phillips.

P. Owner: Guy Baty, NE¼ SE¼ SW¼ sec. 24 T. 57 N., R. 25 W. Total depth 260 feet or 290 feet. The "well starts in Bethany Falls limestone member of Kansas City Formation". Analyzed July 31, 1934 by R. T. Rolufs.

Q. Owner: G. H. Lawson, SW¼ SW¼ SW¼ sec. 2, T. 56 N., R. 25 W. Total depth 421 feet. Water horizon - "Basal Cherokee". Analyzed March 29, 1901 by Paul Schweitzer.

R. Owner: A. T. Cunningham, SW¼ NW¼ NE¼ sec. 18, T. 56 N., R. 24 W. Total depth 206 feet. Collected from tap after passing through pressure tank. Sampled August 27, 1956. Analyst: M. E. Phillips.

Referring to Plate 1, it will be noted that a large area of Livingston County is unfavorably located to obtain water from glacial drift. Wells drilled into the consolidated rock to moderate depths may possibly obtain limited yields of water of marginal quality. The water from "rock" wells in all probabilities will become more mineralized with increased depth of drilling.

QUALITY AND QUANTITY OF WATER FROM STREAMS

The streams of Livingston County, with the exception of the Grand River, are intermittent in their flow. Though the quality of the water is usually satisfactory, the undependable flow makes all streams other than the Grand River unsuitable for irrigation or for municipal use. The Grand River is being used as a water source for municipal needs and to some extent for irrigation.

Two water analyses are available.

CONSTITUENTS	IN PARTS PER MILLION	
	1	2
Turbidity	6	40
Odor	none	none
pH	8.3	8.0
Alkalinity ($CaCO_3$)	222.5	185.5
Phenolpthalein	0.0	0.0
Methyl Orange	222.5	185.5
Carbonate (CO_3)	0.0	0.0
Bicarbonate (HCO_3)	271.5	226.3
Silica (SiO_2)	8.2	7.2
Oxides (Al_2O_3, Fe_2O_3, TiO_2, etc.)	0.6	0.6
Calcium (Ca)	73.7	58.1
Magnesium (Mg)	12.0	11.0
Sodium (Na) and Potassium (K) as Na	16.3	15.7
Total Manganese (Mn)	0.00	0.00
Total Iron (Fe)	0.91	1.06
Dissolved Iron	0.13	0.04
Precipitated Iron	0.78	1.02
Sulfate (SO_4)	33.7	24.5
Chloride (Cl)	5.8	6.5
Nitrate (NO_3)	0.0	0.1
Fluoride (F)	0.2	0.6
Total Suspended Matter	14.	21.
Total Dissolved Solids	298.	248.
Total Hardness	233.5	190.4
Carbonate Hardness	222.5	185.5

CONSTITUENTS	IN PARTS PER MILLION	
	1	2
Non-carbonate Hardness	11.0	4.9
Percent of Alkalies	13	15

1. Shoal Creek, sec. 24, T. 57 N., R. 24 W. Sample collected November 21, 1955. Temperature of the water 44° F., of the air 58° F. Analyst: M. E. Phillips.

2. Grand River, sec. 29, T. 56 N., R. 21 W. Sample collected October 26, 1955. Temperature of the water 58° F., of the air 70° F. Analyst: M. E. Phillips.

The following are stream flow data from: Bolon, Harry C. Surface Waters of Missouri; Missouri Geological Survey and Water Resources, 2d ser., Grand River near Sumner.

Location. - Water-stage recorder, lat. 39° 16' 25", in NE¼ sec. 29, T. 56 N., R. 21 W., at Chicago, Burlington & Quincy Railroad bridge, 2 miles southwest of Sumner and 2½ miles downstream from Locust Creek. Datum of gage is 630.87 feet above mean sea level, datum of 1929. Auxiliary staff gage 3¼ miles downstream. Datum of auxiliary gage is 631.00 feet above mean sea level, datum of 1929. From April 1, 1940 to August 4, 1942, the auxiliary gage was 4 miles downstream.

Drainage Area. - 6,880 square miles.

Records Available. - April 1924 to September 1949.

Average Discharge. - 25 years, 3,850 second-feet.*

Extremes. - 1924-49: Maximum discharge, 180,000 second-feet June 7, 8, 1947 (gage-height, 39.5 feet, from floodmark); minimum observed, 10 second-feet, August 12, 1934. Flood of July 9, 1909 reached a stage of 36.7 feet, from floodmark.

Remarks. - Records fair except those periods of ice effect, which are poor.

Cooperation. - Stationed maintained by Surface Water Branch of the U.S.G.S. in cooperation with the Corps of Engineers.

Medicine Creek near Sturges

Location. - Chain gage on line between sec. 35, T. 59 N., R. 23 W. and sec. 2, T. 58 N., R. 23 W., 3 miles east of Sturges. Zero of gage is 691.60 feet above mean sea level.

Drainage Area. - 368 square miles.

Records Available. - April 1929 to September 1933 (discontinued).

Extremes. - 1929-33: Maximum discharge, 10,400 second-feet April 21, 1929 (gage-height, 15.74 feet) minimum 2.5 second-feet January 9-20, 1931; minimum gage-height, 3.08 feet September 4, 1931.

QUALITY OF WATER FROM GLACIAL DRIFT

In general, the water from the glacial drift is high in total iron,

* one second-foot equals 448.83 gallons per minute.

total dissolved solids, and sulfates. The iron content in the water may cause staining of plumbing fixtures and laundry; however, relatively inexpensive water treatment for the iron will prevent this staining. For most types of irrigation, total dissolved solids should not exceed 2000 parts per million and total alkalies should not exceed 75 percent. Most people cannot tolerate water for drinking purposes which contains more than 1500 parts per million of chloride, or 2000 parts per million sulfate. Water with 300 parts per million of chloride tastes salty to some people. Sulfates in excess of 500 parts per million may have a laxative effect when first used for drinking.

The following are analyses from five glacial drift wells:

CONSTITUENTS	IN PARTS PER MILLION				
	1	2*	3	4	5
Turbidity	35	40	75	15	100
Odor	none	none	none	none	none
pH	7.3	7.15	7.1	6.8	7.3
Alkalinity ($CaCO_3$)	288.5	321.5	380.0	300.5	406.5
Phenolpthalein	0.0	0.0	0.0	0.0	0.0
Methyl Orange	288.5	321.5	380.0	300.5	406.5
Carbonate (CO_3)	0.0	0.0	0.0	0.0	0.0
Bicarbonate (HCO_3)	352.0	392.2	443.6	366.6	495.9
Silica (SiO_2)	21.6	10.5	18.8	16.6	19.0
Oxides (Al_2O_3, Fe_2O_3, TiO_2, etc.)	1.8	2.5	2.2	2.2	1.0
Calcium (Ca)	90.1	224.3	160.2	71.3	98.9
Magnesium (Mg)	14.9	77.6	39.9	16.9	24.8
Sodium (Na) and Potassium (K) as Na	24.5	874.0	91.7	39.9	51.1
Total Manganese (Mn)	0.27	0.13	0.75	1.11	0.18
Total Iron (Fe)	0.90	1.03	2.38	3.10	2.56
Dissolved Iron	0.40	0.52	0.39	0.23	0.25
Precipitated Iron	0.50	0.51	1.99	2.87	2.31
Sulfate (SO_4)	17.8	688.9	311.1	9.6	24.6
Chloride (Cl)	6.3	1160.0	22.0	7.8	4.0
Nitrate (NO_3)	0.0	0.0	0.0	3.2	0.0
Fluoride (F)	0.2	0.4	0.7	0.2	0.3
Total Suspended Matter	7.	0.	16.	0.	21.
Total Dissolved Solids	353.	3403.	956.	358.	475.
Total Hardness	286.3	879.5	564.3	247.6	349.1
Carbonate Hardness	286.3	321.5	380.0	247.6	349.1
Non-carbonate Hardness	0.0	558.0	184.3	none	0.0
Percent of Alkalies	16	68	26	26	24

*although this well is reported as being developed in glacial drift, the analyses suggests that it is a "rock" well.

1. Owner: E. E. Merriott, SW¼ NW¼ NW¼ sec. 6, T. 59 N., R. 23 W. Total depth 105 feet. Sample collected from tap after passing through pressure tank August 28, 1956. Analyst: M. E. Phillips.

2. Owner: George W. Smith, SE¼ SW¼ SE¼ sec. 21, T. 59 N., R. 23 W. Total depth 190 feet. Sampled August 28, 1956. Analyst: M. E. Phillips.

3. Owner: Tall Sexton, SW¼ SW¼ SE¼ sec. 24, T. 58 N., R. 24 W. Total depth 134 feet. Sampled August 28, 1956. Temperature of the water 54° F., of the air 78° F. Analyst: M. E. Phillips.

4. Owner: N. L. Randall, NW¼ SE¼ SW¼ sec. 5, T. 57 N., R. 22 W. Total depth 110 feet. Collected after passing through the pressure tank October 5, 1956. Analyst: M. E. Phillips.

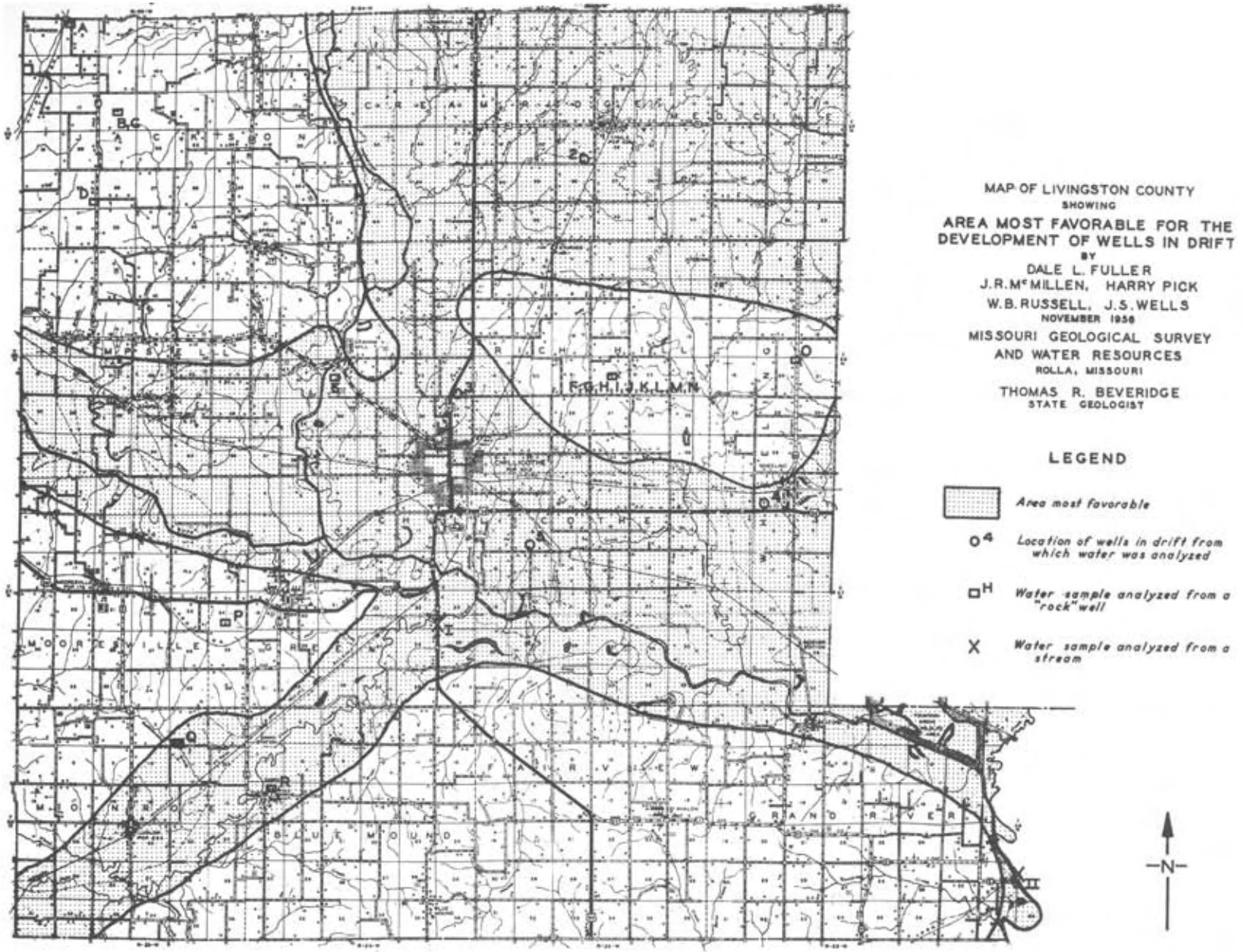
5. Owner: W. R. Grace, NE¼ SE¼ SW¼ sec. 8, T. 57 N., R. 23 W. Total depth 135 feet. Sample collected from hydrant after passing through pressure tank August 28, 1956. Analyst: M. E. Phillips.

QUANTITY OF WATER FROM GLACIAL DRIFT

DOMESTIC WELLS - Included in this category are wells developed for household or general farm use. Yields required from domestic wells vary but seldom exceed 15 gallons per minute. In some parts of Livingston County sands and gravels were not deposited in the glacial drift. There are also areas where the glacial drift cover is relatively thin or lacking. In such areas the possibility of developing wells is limited. Plate 1 shows the area most favorable for the development of domestic wells. Plate 3 is a contour map showing the elevation of bedrock above sea level. To determine probable drilling depths, the elevation of the bedrock should be subtracted from the surface elevation for each specific site. Plate 3 shows the locations of the test holes and the thickness of the glacial drift encountered.

IRRIGATION WELLS - Included in this category are all high yield wells whether used by cities, by industries, or for irrigation. Plate 2 shows the area most favorable for the development of irrigation wells. Also shown are the locations of seven wells which flowed. Although not everywhere is it shown as favorable on Plate 2, the Grand River Valley may possibly be capable of supporting irrigation wells throughout its length.

With proper development, yields of 200-1000 gallons per minute may be obtained. An irrigation well 80 feet deep located in the Grand River Valley has a yield of 800 gallons per minute. Yields to be expected are contingent upon several factors:


MAP OF LIVINGSTON COUNTY
SHOWING
AREA MOST FAVORABLE FOR THE DEVELOPMENT OF WELLS IN DRIFT
BY
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J.R.McMILLEN, HARRY PICK
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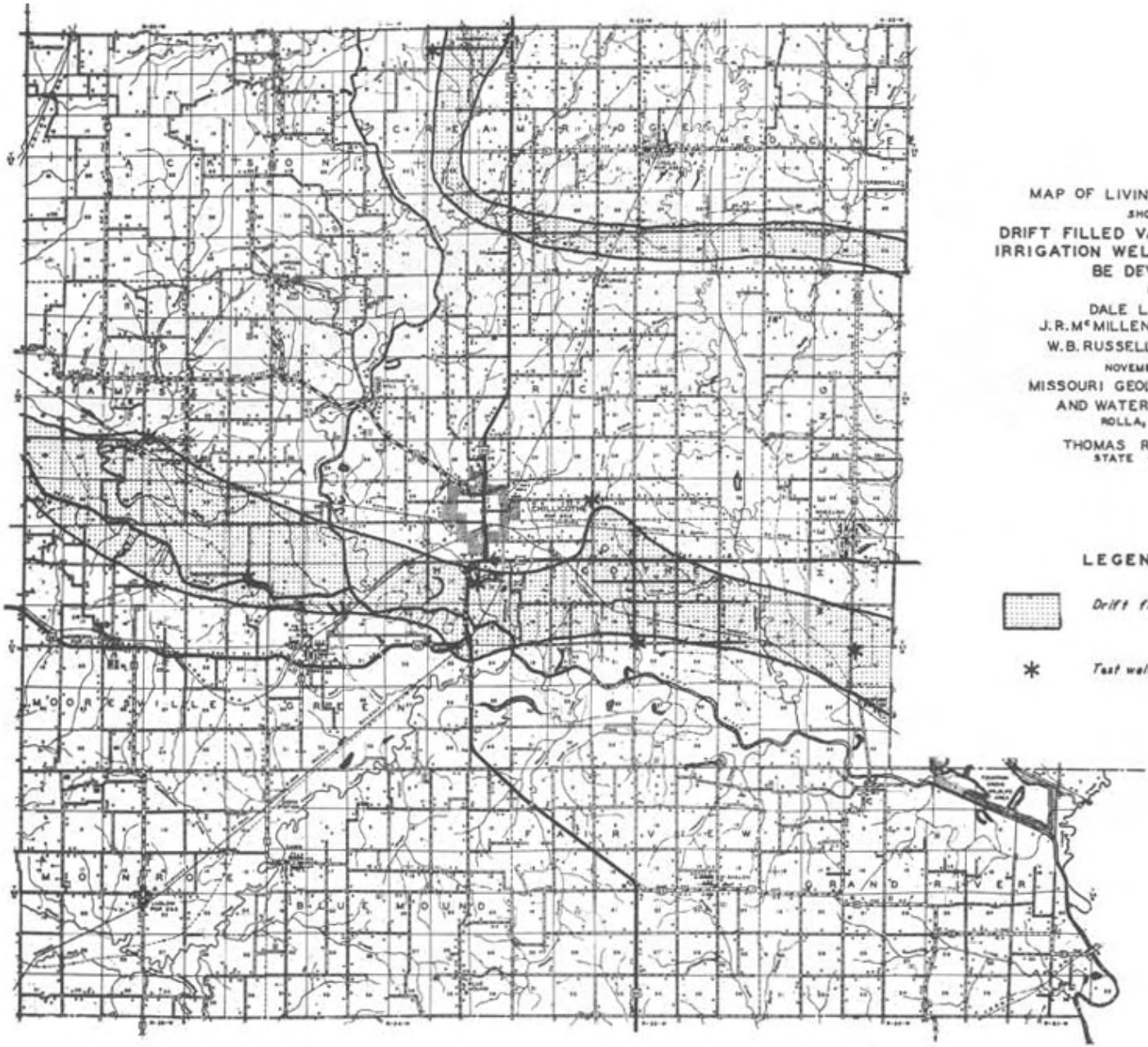
NOVEMBER 1956
MISSOURI GEOLOGICAL SURVEY
AND WATER RESOURCES
ROLLA, MISSOURI
THOMAS R. BEVERIDGE
STATE GEOLOGIST
LEGEND
Area most favorable
Location of wells in drift from which water was analyzed
Water sample analyzed from a "rock" well
Water sample analyzed from a stream
N
Base by the Missouri State Highway Department, 1950

PLATE I



MAP OF LIVINGSTON COUNTY
SHOWING
DRIFT FILLED VALLEYS IN WHICH IRRIGATION WELLS POSSIBLY CAN BE DEVELOPED
BY
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NOVEMBER 1956
MISSOURI GEOLOGICAL SURVEY AND WATER RESOURCES
ROLLA, MISSOURI
THOMAS R. BEVERIDGE
STATE GEOLOGIST

LEGEND

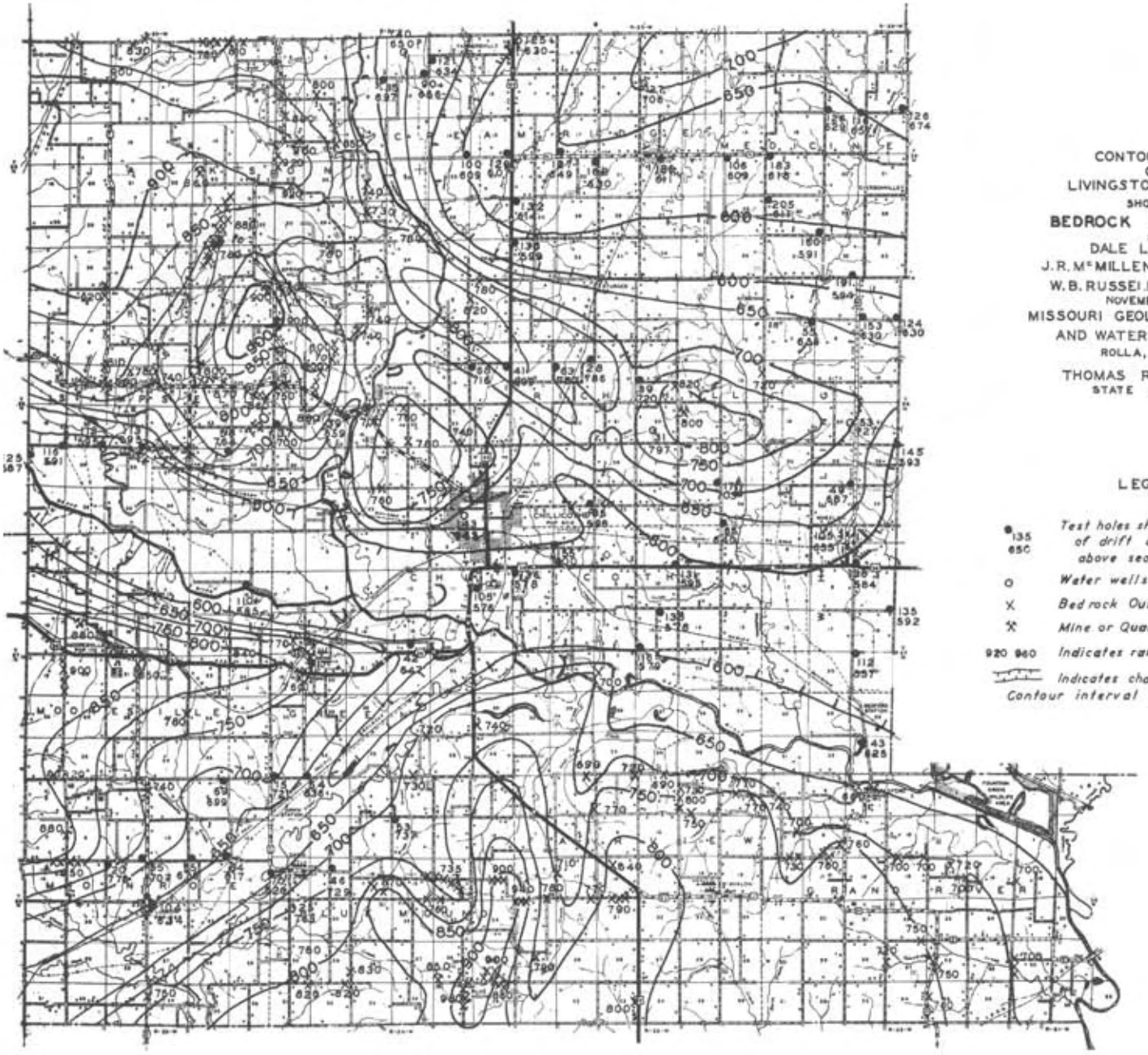
Drift filled valley

* Test wells that flowed

N

Base by the Missouri State Highway Department, 1950

PLATE 2



CONTOUR MAP
OF
LIVINGSTON COUNTY
SHOWING
BEDROCK ELEVATIONS
BY
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J.R. McMILLEN, HARRY PICK
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MISSOURI GEOLOGICAL SURVEY
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THOMAS R. BEVERIDGE
STATE GEOLOGIST

LEGEND

- 135 / 650 — *Test holes showing thickness in feet of drift and elevation of bedrock above sea level.*
- *Water wells*
- *Bedrock Outcrops*
- *Mine or Quarry*
- 920 960 — *Indicates range of outcrop elevation*
- *Indicates channel*

Contour interval 50 feet

N

Base by the Missouri State Highway Department, 1950

PLATE 3

(1) The thickness of the sand and gravel beds.
(2) The size and sorting of the sand and gravel.
(3) The manner of construction and materials used, such as proper well screen, gravel pact, etc.
(4) Ability of the well driller to develop the full capacity of the water bearing sands.

Continued successful production is contingent upon:

(1) Re-charge rate of the water-bearing horizons.
(2) Quality of the screen and materials used.
(3) Subsequent well treatment such as acidizing.
(4) Avoidance of over-pumpage.

SUMMARY

Approximately 35,000 acres of Livingston County are located within the area in which irrigation wells possibly can be developed. Nearly one-half of Livingston County's area is suitably located for obtaining water sufficient for domestic needs from the glacial drift.

Questions concerning water problems for a specific location should be sent to the Missouri Geological Survey, P. O. Box 250, Rolla, Missouri 65401.